BUREAU OF WATER

Methodology for Determining a Permitted Dissolved Oxygen Deficit Allowance for Waters Not Meeting Numeric Standards Due to Natural Conditions

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PROMOTE PROTECT PROSPER
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GLOSSARY

Adverse impact or effects refers to an alteration of the natural conditions to a point where biological, toxicological, or chemical changes indicate an impairment to the environment. The Department will use multiple methods and/or indicators to determine adverse impacts that include, but are not limited to, the following:

- a significant change in biological productivity;
- a significant increase in abundance or distribution of nuisance species;
- a significant reduction in the successful completion of the life cycle of species.

Background (see Natural conditions) refers to the levels of dissolved oxygen (DO)found in the natural conditions.

Balanced indigenous aquatic community means a natural, diverse biotic community characterized by the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination of pollutant tolerant species (S.C.Regulation 61-68).

Candidate site refers to the location of the existing or proposed discharge and the surrounding affected area.

Chlorophyll *a* is a type of chlorophyll present in all types of algae, sometimes in direct proportion to the biomass of the algae (EPA-440/4-90-006). It is used as a measure of algal biomass. Chlorophyll *a* is a good indicator of algal concentrations and of nutrient overenrichment. Excessive phytoplankton concentrations, as indicated by high chlorophyll *a* levels, can cause adverse DO impacts such as:

- wide diurnal variation in surface DO due to daytime photosynthesis and nighttime respiration, and
- depletion of bottom DO through the decomposition of dead algae (EPA-823-B-94-005a).

Classified uses means those uses specified in Section G of R.61-68 for surface water and Section H of R.61-68 for ground waters, whether or not those uses are being attained (S.C. Regulation 61-68).

Critical conditions are those background environmental conditions used for wasteload allocation modeling purposes where dissolved oxygen and its interactive parameters are such that the predicted dissolved oxygen concentration ensures compliance with applicable water quality standards.

Critical life stage is the period of time in an organism's life span in which it is the most susceptible to adverse effects caused by exposure to toxicants, usually during early development (egg, embryo, larvae). Chronic toxicity tests are often run on critical life stages to replace long duration, life-cycle tests since the most toxic effect usually occurs during the critical life stage (EPA/505/2-90-001). This is also true of toxic conditions due to hypoxia.

Deletion process refers to the United States Environmental Protection Agency's (USEPA) procedure for reviewing data sets for the deletion of nonrepresentative species (refer to EPA-823-B-94-001).

Dissolved Oxygen (DO) refers to the concentration of oxygen found in waterbodies. DO levels in natural waters and wastewaters depend on the physical, chemical, and biochemical activities in the waterbody (*Standard Methods*, 19th edition).

Load allocation (LA) is the portion of a receiving water TMDL that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources (EPA-823-B-94-005a).

Natural conditions means those water quality conditions unaffected by point and nonpoint sources or other sources of pollution (S.C. Regulation 61-68). This includes all pollution of anthropogenic origin.

Nutrient is an elemental or chemical essential to life, such as carbon, oxygen, nitrogen, and phosphorus (EPA-440/4-90-006).

Propagation means the continuance of species through reproduction and growth in the natural environment, as opposed to the maintenance of species by artificial culture and stocking (S.C.Regulation 61-68).

Reference site refers to an area or areas of least impacted habitat and conditions that best reflect those found at the candidate site.

Resident species refer to those species which "occur at the site." "Occur at the site" is described in the text of the document.

Site-specific data set refers to all existing and pertinent data applicable to the candidate site.

Total Maximum Daily Load (TMDL) is the sum of the individual waste load allocations (WLAs) and load allocations (LAs); a margin of safety is included with the two types of allocations so that any additional loading, regardless of source, would not produce a violation of water quality standards (EPA-823-B-94-005a).

Waste load allocation (WLA) is the portion of a receiving water's TMDL that is allocated to one of its existing or future point sources of pollution (EPA-823-B-94-005a).

Water quality standards (WQS) are provisions of State or Federal law which consist of a designated (classified) use or uses for the waters of the United States, water quality criteria, expressed in numeric or narrative form, for such waters based upon such uses, and an antidegradation policy that protects existing uses and provides a mechanism for maintaining high water quality. Water quality standards are to protect public health or welfare, enhance the quality of the water and serve the purposes of the Federal Clean Water Act and the S.C. Pollution Control Act.

A. INTRODUCTION

S.C. Regulation 61-68, Water Classifications and Standards (R.61-68)[1], establishes an allowable deficit for dissolved oxygen (DO) in those waters that do not meet the numeric water quality standard due to natural conditions. During the most recent triennial review of the water quality standards, the Department reviewed the existing allowable deficit of 0.10 mg/l of dissolved oxygen and determined, with the assistance and full support of the United States Environmental Protection Agency (USEPA), that the 0.10 mg/l allowable dissolved oxygen deficit would be kept as a *de minimis* amount and that an alternative amount of a maximum of 10% of the natural condition would be allowed, if and only if, certain specific criteria were fulfilled. This methodology was developed as a cooperative effort by the Department, in consultation with the USEPA and the South Carolina Department of Natural Resources (DNR), to describe application of the revised portion of the regulation. This methodology document describes a site-specific permit effluent derivation process which will be initiated when an applicant for a National Pollutant Discharge Elimination System (NPDES) permit requests consideration for application of the 10% allowable deficit regulation. Permits issued through the NPDES program must include public participation and an opportunity for public comment; therefore any use of this methodology would also be subject to public participation during the permit review period.

Recent amendments to the S.C. Pollution Control Act (the Act)[2] require that the Department provide for additional public participation when any applicant informs the Department of its intent to apply for the application of the ten percent deficit. The Act states, "A party seeking a site-specific effluent limit related to dissolved oxygen pursuant to this section must notify the department in writing of its intent to obtain the depression. Upon receipt of the written notice of this intent, the department shall within thirty days publish a public notice indicating the party seeking the dissolved oxygen depression and the specific site for which the dissolved oxygen depression is sought in addition to the department's usual public notice procedures. The notice shall be in the form of an advertisement in a newspaper of statewide circulation and in the local newspaper with the greatest general circulation in the affected area. If within thirty days of the publication of the public notice the department receives a request to hold a public hearing from at least twenty citizens or residents of the county or counties affected, the department shall conduct a hearing. The hearing must be conducted at an appropriate location near the specific site for which the dissolved oxygen depression is sought and must be held within ninety days of the publication of the initial public notice by the department." The Department will document and provide a response to comments received.

The following is an overview that outlines the methodology the Department will use to determine whether to allow a maximum of a 10% deficit in waters not meeting numerical standards due to natural conditions. A more detailed methodology follows the overview. The Department will attempt to keep the review period for initial and intermediate steps to a minimum depending on the complexity of the situation. The Department shall provide the United States Fish and Wildlife Service (USFWS), the United States Geological Survey (USGS), the National Ocean Service (NOS), the National Marine Fisheries Service (NMFS), and the DNR a sixty day period to review and provide comments on the design of the scientific study. The Department and the DNR shall select and convene a science peer review committee to review the design of the study. The Department and the USEPA must concur on the final design before the study is initiated. Justification to the study design must be based solely on scientific considerations that demonstrate resident aquatic species will not be adversely affected. Objections to the study design must be provided in writing by the Department to the party seeking a site-specific effluent limit related to dissolved oxygen[2].

B. OVERVIEW

Step 1) Determine if the present DO conditions at the site where the existing or proposed discharge is or will be located do not meet numeric standards due to natural conditions.

This first step is essential to ascertaining the natural dissolved oxygen levels found at the existing or proposed discharge location (hereafter known as the "candidate site"). It is these "background" levels that will be used in the process of determining whether to allow application of the "10% deficit rule." There are two acceptable methods for making the determination. The preferred method is to find reference conditions which reflect the candidate site conditions. The second method, which only can be used if reference conditions cannot be found, is the use of a Department approved, calibrated, and verified dynamic water quality model or, if available, a multidimensional dynamic water quality model specifically developed for the candidate site. If it is determined that the existing low dissolved oxygen concentrations are due to anthropogenic sources, including atmospheric deposition of nitrogen compounds, then the candidate site will not be eligible for the application of the 10% deficit allowance.

Step 2) Assess the biological conditions at the candidate site and, where applicable, the reference site.

This step includes extensive examination of the candidate site and, where applicable, the reference site to ensure that all resident species are identified and represented and, therefore, protected if the 10% deficit is allowed. The intent is to protect sensitive species, thereby protecting all species.

Step 3) Compare the data assembled at the candidate site and, where applicable, the reference site with the data set that the USEPA has already assembled.

This step ensures compatibility with national procedures. This will require using a process developed by the USEPA for site-specific data sets and known as the deletion process.

Step 4) Assess the biological requirements based on the data assembled in the site-specific data set.

This process will determine the necessary dissolved oxygen requirements using the USEPA's biological saltwater DO criteria development approach (see pg. 11). This model will give the critical DO requirements for the biota represented at the candidate site.

Step 5) Compare the biological dissolved oxygen requirements (output from the saltwater DO criteria development approach) and the predicted levels of dissolved oxygen at the candidate site (derived from the reference site or the water quality model) using "background" minus the 10%.

This step ensures that all critical species and critical life stages and time periods for dissolved oxygen requirements will be met if a 10% deficit is allowed. The levels of dissolved oxygen for the candidate site are generated using a site-specific dynamic water quality model or, if available, a site-specific multidimensional dynamic water quality model with the 10% deficit taken from the obtained "background" levels. This model predicted DO is compared to the output of the saltwater DO criteria development approach which generates the necessary levels of dissolved oxygen for nonimpact to the resident species. If this comparison indicates that a full 10% deficit would adversely affect the resident species, the deficit would be based on the necessary levels of dissolved oxygen indicated by the saltwater DO criteria development approach. The critical condition model used for this comparison should be the model used for wasteload allocation(s) for the candidate site.

Step 6) Approval by the Department and the USEPA of any allowances of the 10% deficit with the Department maintaining the site-specific information.

Any approvals of wasteload allocations for oxygen demanding substances based on the above procedures will be entered into a Department database of the areas where the 10% or other appropriate allowance based on the biota has been approved.

C. DETAILED METHODOLOGY

Step 1) Determine if the present DO conditions at the site where the existing or proposed discharge is or will be located do not meet numeric standards due to natural conditions.

In order to meet the requirements of the regulation, the natural levels of dissolved oxygen existing at the candidate site must be determined so it can be used as the background levels when assessing the appropriateness of a 10% deficit. In accordance with the regulations, any waterbody where natural conditions alone create dissolved oxygen concentrations less than 110% of the applicable water quality standard is eligible for applying this allowance. This methodology may be used for marine, freshwater-saltwater transitional areas, and freshwaters. In those waters where freshwater species cohabitate with marine species, existing and new data and information will be used to represent the freshwater species just as with the marine species. In those freshwater only cases, the methodology will need to be amended to remove references to USEPA's biological saltwater DO criteria development approach and substitute the determination utilized by the USEPA for development of the 1986 water quality criteria for dissolved oxygen [3].

R.61.68.D.4 states: "Certain **natural conditions** may cause a depression of dissolved oxygen in surface waters while existing and classified uses are still maintained."(Emphasis added) So, the first step is to determine if the waterbody area where the discharge is or shall be located and its impacted area is naturally low in dissolved oxygen.

R.61-68 defines natural conditions as: "those water quality conditions unaffected by point and nonpoint sources or other sources of pollution." These sources refer to all anthropogenic sources of pollution, including air deposition of nitrogen compounds, and must be addressed in order to determine the natural conditions.

To determine natural conditions, the following two methods may be used: a) establishment of conditions at the reference site and b) use of a mathematical model for determining natural conditions. Of the two methods, the Department prefers the use of a reference site for the determination of natural conditions.

a. Establishment of Conditions at the Reference Site

Since it is important that the reference site conditions (hereafter known as the "reference site") reflect the ecological and environmental conditions present at the candidate site, the reference site should be morphologically and hydrologically as similar to the candidate site as possible with a similar salinity regime and resident biotic community. The reference site should be in a watershed with a minimal amount of disturbance. Impacts from urbanization and agriculture should be minimal and natural vegetation should dominate the land cover. There should also be an appropriate diversity of substrate. Point source discharges should be absent or distant from the site (determination of the distance from the point source discharges will be made on a case-by-case basis).

After the reference site is selected, it must be approved as part of a proposed study plan submitted by the applicant. The reference site is not limited to the State, but must have similar geography, environmental setting, and climatic conditions.

Site-specific data at both the reference site and candidate site will be required of the applicant. At a minimum, the Department will require continuously collected data (e.g., DO, temperature, salinity, pH) combined with data from periodic grab sampling (e.g., ammonia, nutrients, BOD) for analyses for a period of one year (winter, spring, summer, fall) for both sites. The period of record should include all seasons, a range of freshwater inflows, storm events, and a range of tidal heights. While the Department is aware that continuously collected data may have unavoidable periods of incomplete records due to instrumentation malfunction, need for calibration, etc.; there will be a minimum acceptable level of data collection to be specified by the Department. If abnormal meteorological conditions occur within a one year study period and disrupts the data set, another year of sampling may be required and an acceptable range of variability of the distribution may be considered based on existing longterm on-site data. The data set must include, but is not necessarily limited to, the following:

Ammonia	BOD_5
Chlorophyll *a*	Dissolved Oxygen
Nitrate / Nitrite	pH
Phosphorus	Salinity
Specific Conductance	Stream Flow or Stage Data
Temperature	Total Kjeldahl Nitrogen

The Department prefers the water samples to be depth profiled (top, middle, and bottom), but understands that there may be site-specific conditions where this may be unnecessary or it may be difficult to maintain continuous monitors at all three depths; therefore, the Department may decide to accept less than all three as appropriate. The Department will also require that air deposition of nitrogen be addressed on a case-by-case basis. USEPA-approved deployment methods for continuous monitoring equipment must be used and only USEPA-approved analytical methodologies may be used for sample analyses. The samples must represent critical (dependent on life stages) and non-critical time periods based on the resident species and flow conditions.

The applicant must substantiate why an appropriate reference site cannot be used before method b) may be considered for use.

All data and information collected in Step1(a) will be used to assist the Department in its determination of the natural conditions that presently exist or potentially should exist at the candidate site. If method b) is applied then all data and information collected will also be used for calibration and verification of the dynamic water quality model that will be used later in the process.

b. Mathematical Model Use for Identification of Natural Conditions

In the event that an appropriate reference site cannot be used to determine natural conditions, an applicant may choose to develop a site-specific dynamic water quality model or, if available, a site-specific multidimensional dynamic water quality model capable of capturing spatial and temporal variability necessary for evaluation of DO exposure periods. The selected modeling methodology must be approved by the Department prior to its use. The water quality model specifically developed for the candidate site must be used for determining natural conditions. The model should be the same one used for determination of wasteload allocations during critical conditions at the candidate site. If after extensive review, the Department finds that the model responds appropriately spatially and temporally with the identified point and nonpoint sources of loading and within an acceptable margin of error can reflect the natural conditions of the waterbody, then the Department may verify the results (more than one data set from multiple seasons will be used) and allow the model to be used to indicate the natural conditions for dissolved oxygen at the candidate site.

Once the assessment of the reference site is completed or the applicable dynamic water quality model has been approved and utilized, the background levels of dissolved oxygen for the candidate site will be established. This background or natural DO levels will be used to assess application of the 10% deficit rule.

Step 2) Assess the biological conditions at the candidate site and, where applicable, the reference site.

The next step in the process is to ensure that the resident species will be protected. R.61-68.D.4.b. states that "dissolved oxygen depression greater than 0.1 mg/l shall not be allowed **unless it is demonstrated that resident aquatic species shall not be adversely affected.**" (Emphasis added). To address this regulatory requirement, an extensive biological assessment of the candidate site must be conducted. All species (including any freshwater species) must be represented. The applicant will be required to submit appropriate data. If at any time during this process it becomes evident that the candidate site does not meet the necessary conditions to support propagation of a balanced indigenous aquatic community, no additional depression of dissolved oxygen will be allowed and the waterbody will be identified as impaired. The required data will include, but are not necessarily limited to, the following:

a. An In-depth Literature Search

An in-depth literature search (including any pertinent databases) will be conducted that will indicate the full array of species that will or should "occur at the site" for the candidate site. The phrase occur at the site[3] includes the species, genera, families, orders, classes, and phyla that:

- are usually present at the site.
- are present at the site only seasonally due to migration.
- are present intermittently because they periodically return to or extend their ranges into the site.
- were present at the site in the past, are not currently present at the site due to degraded conditions.
- are present in similar nearby waterbodies or that are not currently present at the site due to degraded conditions, and are expected to be at the site under natural conditions.

The above description of what "occurs at the site" is also referred to as the resident species.

b. Sampling

Sampling will be conducted at the candidate site and the reference site. The following are general guidelines for sampling of faunal taxa. Sampling should be conducted on a quarterly basis for at least a year before finalizing a list of species. An "area" is a subsite which is segregated from other areas due to unique attributes of hydrology, salinity, and/or sediment type within a site. Sampling "stations" are specific locations within an area at which samples or sample replicates are collected. The number of areas, sampling stations, and replicate samples is dependent upon the size and complexity of a site. These numbers would be determined on a site-specific basis and are subject to recommendations and approval of the Department and the USEPA in consultation with the DNR, and other agencies as needed.

Areas of different salinity regimes within a site should be roughly segregated (i.e., oligohaline, mesohaline, polyhaline, and euhaline). Also, salinity stratification would need to be considered. Within areas of differing salinity regimes, bottom types should be segregated and sampled for infaunal organisms. Bottom types should include shallow and deep water fine grain sediments, coarse grained high energy channels, and open bay, tidal creek, cove, and river mouth habitats, if present, to provide for thorough infaunal sampling. Sediment characterization should be conducted to insure that all bottom habitats are sampled and to verify that the diversities of these habitats are similar between the candidate site and the reference site.

It is anticipated that individual areas would be transected and sampling stations chosen as recommended by reviewing biologists. At candidate sites containing small tidal creeks draining to larger river systems, a significant number (determined on a case-by-case basis) of the tidal creeks must also be sampled.

Types of habitat to be sampled and general sampling techniques to be considered will include, but are not limited to, the following:

- INFAUNAL: Drop dredge (ponar grab sampler, Van Veen grab sampler, etc.)
- EPIFAUNAL: Bottom trawl with tickler chain, sled dredge, block net (tidal creek)
- NEKTON: Trawl, gill net, trammel net, blocknet, seine, electrofishing, etc.
- PLANKTON: Plankton tow
- INTERTIDAL OYSTER REEF (hard substrate): Box corer or quadrate sampling

The determination of specific sampling techniques will depend on the presence and abundance of habitats and should be determined as recommended by the Department and the USEPA in consultation with the DNR.

c. Critical Species

The Department will require that critical species for South Carolina that are not represented in the DO exposure test data set developed by the USEPA be incorporated into the site-specific data set. If a species is not a critical species, it will be represented by data collected for a surrogate species that will be determined appropriate by the Department and the USEPA in consultation with the DNR. Critical species[4] are those commercially or recreationally important at the site, those that exist at the site and are listed as threatened or endangered under Section 4 of the Endangered Species Act, or for which there is evidence that the loss of the species from the site would likely cause an unacceptable impact on a commercially or recreationally important species, a threatened or endangered species, the abundances of a variety of other species, or the structure or function of the balanced indigenous aquatic community. In order to ensure the representation of critical species in the site-specific data set, DO exposure tests will be conducted on a subset of the "resident species" (obtained from Step 2.a. and b.). The representative subset will need to be species (and life stages) that occur at the site, are known to be sensitive to low DO levels, and contain a range of trophic functions (e.g., top predator, forage, bottom dwelling, planktonic, etc.). Rare and endangered species usually represent biota that are experiencing population declines from a range of stressors and any rare or endangered species that occur at the site must be included in the evaluation process. While it may not be possible to conduct tolerance tests to mortality end points on endangered species, data (usually literature) that will represent those determined to occur at the site must be included. Some additional testing may be warranted for some species already included in the existing USEPA data set in order to obtain appropriate data that will address concerns regarding the variability of DO tolerances and physiological adaption in State waters. The Department and the USEPA in consultation with the DNR will determine what critical species will comprise the subset for testing on a case-by-case basis.

Data must be available for all life stages and specifically for those identified important life stages. The tolerance/responses of fingerlings and juveniles/adults to exposure to low DO may be very different. Whenever possible the stocks need to be of South Carolina origin; otherwise, they may not reflect the appropriate degree of tolerance. A major concern which must be addressed is the ability to obtain the early life stages of the organisms for testing purposes. Therefore, the testing laboratory may necessarily need to spawn the organisms.

The following is a noninclusive representative sampling of some critical species identified for South Carolina:

- RED DRUM: fingerling, juvenile and 1-2 yr old life stages
- SHORTNOSE STURGEON: fingerling and juvenile life stages
- ATLANTIC STURGEON: fingerling and juvenile life stages
- WHITE SHRIMP: post larvae and juvenile life stages (*P. setiferous* from SC waters)
- BROWN SHRIMP: post larvae and juvenile life stages (*P. aztecus* from SC waters)
- STRIPED MULLET: fingerling and juvenile life stages
- SOUTHERN FLOUNDER: fingerling and juvenile life stages
- SPOTTED SEA TROUT: fingerling and juvenile life stages
- STRIPED BASS: larvae and juvenile life stages
- AMERICAN SHAD: larvae and juvenile life stages
- HICKORY SHAD: larvae and juvenile life stages
- BLUEBACK HERRING: larvae and juvenile life stages

Dissolved Oxygen Toxicity Data and Testing Protocol

Dissolved oxygen toxicity data on critical species and critical life stages must be acquired by the applicant. To ensure the data is accurate, reliable, and consistent with the existing USEPA data set, the testing protocol which was used by the USEPA will be used when conducting the dissolved oxygen testing. The testing procedures have been supplied to the Department by the USEPA with approval for their use. These testing procedures[5,6,7] should be referenced for toxicity testing information. Test conditions used in creating the existing USEPA data set will need to be modified to reflect conditions found in waters of the State (e.g., higher temperatures). The USEPA's National Health and Environmental Effects Research Laboratory (NHEERL) in Gulf Breeze, Florida, has developed a modified DO test system for marine organisms that has not yet been published, but the Department and the USEPA in consultation with the DNR are willing to consider this modification for use in the testing protocols.

Any additions to the existing USEPA data set must be approved by the Department and the USEPA.

Step 3) Compare the data assembled at the candidate site and, where applicable, the reference site with the data set that the USEPA has already assembled.

Once all toxicity data has been acquired for the critical species at the site and sampling of the required biological assemblages for the reference site and the candidate site have been completed, the Department will review the existing USEPA data set to ensure that all available data that may be protective of resident species has been included in the site-specific data set. This review is done by the process of deleting species that do not occur at the site or do not represent species that occur at the site from the existing USEPA data set and retaining the species left for inclusion in the site-specific data set. This process is a well established USEPA procedure[4] and is described below. Selective deletions of the existing USEPA data set are not allowed. If any species is to be deleted, the deletion process must be applied to all species in the existing USEPA data set, after any necessary corrections and additions have been made. The following is the USEPA deletion process.

- Review the existing USEPA data set.
- Make USEPA approved corrections and/or additions to the existing USEPA data set.
- Group all the species in the data set taxonomically by phylum, class, order, family, genus, and species.

- Circle each species that satisfies the definition of "occur at the site" as presented above, including any data for species that are approved surrogates of threatened or endangered species which occur at the site.
- Use the following step-wise process to determine which of the uncircled species must be deleted and which species must not be deleted.

A) *Does the genus occur at the site?* If no, go to *B.*
If yes, are there one or more species in the genus that occur at the site but are not in the data set?
If no, go to *B.*
If yes, retain the uncircled species.

B) *Does the family occur at the site?* If no, go to *C.*
If yes, are there one or more genera in the family that occur at the site but are not in the data set?
If no, go to *C.*
If yes, retain the uncircled species. *

C) *Does the order occur at the site?* If no, go to *D.*
If yes, does the data set contain a circled species that is in the same order?
If no, retain the uncircled species. *
If yes, delete the uncircled species. *

D) *Does the class occur at the site?* If no, go to *E*.
If yes, does the data set contain a circled species that is in the same class?
If no, retain the uncircled species. *
If yes, delete the uncircled species. *

E) *Does the phylum occur at the site?* If no, delete the uncircled species. *
If yes, does the data set contain a circled species that is in the same phylum?
If no, retain the uncircled species. *
If yes, delete the uncircled species. *

* Continue the deletion process by starting at *A* for another uncircled species until all uncircled species in the data set have been considered.

The species that are circled and those that are retained constitute the site-specific data set. It is this data set that will be used in Step 4 to ensure that all resident species are protected.

Step 4) Assess the biological requirements based on the data assembled in the site-specific data set.

Once all resident species have been represented by the site-specific data set, the Department will use a saltwater DO criteria development approach developed by the USEPA (Thursby, *et al*., 1997)[8] to determine the exposure requirements for dissolved oxygen based on the site-specific data set. The USEPA approach addresses both continuous hypoxic exposure (24 hours or more) and cyclic hypoxic exposure (less than 24 hours, but possibly repeated over a series of days) for saltwater animals. Three areas of protection are developed.

a. Protection for Juvenile and Adult Survival (acute effects)

i. A lower limit is derived for continuous exposures using Final Acute Value (FAV) calculation procedures outlined in the USEPA document "Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" (Stephan, et al., 1985)[9], but using data only for juvenile or adult life stages.

ii. Protection under cyclic conditions is derived using an appropriate time-to-death curve for juveniles exposed for less than 24 hours.

b. Protection for Growth (chronic effects)

i. A threshold above which long-term continuous exposures should not cause unacceptable effects is derived using mostly larval growth data and the FAV calculation procedures.

ii. Cyclic exposures are evaluated by measuring growth reductions from cyclic exposures and comparing them to expected reductions based on continuous exposures.

c. Protection for Recruitment Effects (population level protection)

For sites with constant exposures between the acute and chronic dissolved oxygen (DO) criteria values and for non-constant regimes, protective limits are developed based on a cumulative larval recruitment model, using a representative species. Larvae are more sensitive than juveniles, but protection limits are not being established to protect individual larvae. Instead, the approach estimates how many days a given DO concentration can be tolerated without causing unacceptable effects on larval survival in relation to recruitment. Once the juvenile stage is reached, the acute and chronic protective limits apply.

The most sensitive species and larval life stage tested (i.e., one that has a high DO response threshold) are used for development of the protective value for recruitment. (For example, larval crustaceans are among the most acutely and chronically sensitive larval saltwater animals.) The larval stage chosen must be present or representative of species found in the water column at the time of the expected hypoxia season. Also, it is important to have information on the species' life history, with respect to reproduction and recruitment.

The larval recruitment model is used to project effects from exposure to various low DO concentrations for various lengths of time.

i. The output from the model that protects against cumulative recruitment impairment greater than 5% estimates protection against continuous exposure.

ii. For cyclic exposures, the expected larval percentage mortality is projected for a representative cycle. With the aid of the model output, that information is then used to determine over how many days the predicted rate of mortality can occur and still not impair the cumulative seasonal recruitment by greater than 5%.

Step 5) Compare the biological dissolved oxygen requirements (output from the saltwater DO criteria development approach) and the predicted levels of dissolved oxygen at the candidate site (derived from the reference site or the water quality model) using "background" minus the 10%.

Now that the site-specific data set has been examined via the saltwater DO criteria development approach and specific dissolved oxygen requirements have been generated, a comparison of the dissolved oxygen requirements associated with the identified resident species and the deficit depression from the background levels of dissolved oxygen will need to be evaluated. This evaluation will allow the Department to determine if there are likely to be any adverse effects associated with the allowance of a 10% depression for dissolved oxygen from the natural conditions.

The site-specific dynamic water quality model or, if available, the site-specific multidimensional water quality model developed for the candidate site (that may also be the model developed for wasteload allocations during critical conditions) will be used to determine the 10% deficit from natural conditions. Once those levels have been determined, they will be compared to the levels generated by the saltwater DO criteria development approach for the resident species in the site-specific data set. If at any time the predicted DO levels of the applicable water quality

model indicates the dissolved oxygen levels will fall below the levels generated by the saltwater DO criteria development approach necessary to sustain and protect the resident biota, then only the deficit indicated by the saltwater DO criteria development approach will be allowed. If the levels generated by the model predict that all levels of DO will be at a level that will be protective of the resident species, then a deficit may be allowed up to 10%. If the model predicts DO levels consistently below levels predicted as needed by the saltwater DO criteria development approach, the waterbody will be identified as impaired and no additional DO deficits will be allowed and the Department will take appropriate actions to address the impairment to ensure compliance with water quality standards.

Section D.4.c. of R.61-68 states "dissolved oxygen concentrations shall not be cumulatively lowered more than the deficit described (in sections a and b) utilizing a daily average unless it can be demonstrated that resident aquatic species shall not be adversely affected by an alternate averaging period." The section allows the Department to determine the appropriate time scale for use in the site-specific dynamic water quality model or, if available, the site-specific multidimensional dynamic water quality model based on the requirements of the resident species. Therefore, the appropriate time scale will be determined at the time the model is being used to determine the deficit levels.

Step 6) Approval of any allowances of the 10% deficit with the Department maintaining the site-specific information.

The Department shall provide the USFWS, the USGS, the NOS, and the NMFS a sixty day period to review and provide comments on the results of the scientific studies. After review, the Department, the USEPA, and the DNR must concur that the results of the study justify implementation of a dissolved oxygen deficit allowance of up to ten percent. In reaching a decision on the study results, the Department and the DNR must base their decision upon the entire record, taking into account whatever in the record detracts from the weight of the decision, and must be supported by evidence that a reasonable mind might accept as adequate to support the decision. Objections to the acceptance of the results of the study must be provided in writing by the Department to the party seeking a site-specific effluent limit related to dissolved oxygen[2]. If approved, the Department will delineate the affected area within the specific waterbody and maintain this in a database for all waterbodies where this type action has been approved. The database will contain all applicable information regarding the boundaries of the affected area and the dissolved oxygen requirements for the waterbody.

REFERENCES

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5. ASTM 1992. Standard Guide for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians. In: Annual Book of ASTM Standards, E 729-88a, pp. 403-422. American Society for Testing and Materials, Philadelphia, PA, USA.

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7. Miller, D.C., D.E. Body, J.C. Sinnet, S.L. Poucher, J. Sewall, and D.J. Sleczkowski. 1994. A reduced dissolved oxygen test system for marine organisms. Aquaculture 123: 167-171.
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